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TECHNICAL NOTE

No. 1524

TAKE-OFF PERFORMANCE OF LIGHT TWIN-FLOAT SEAPLANES

By John B. Parkinson

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

Washington
February 1948

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E R R A T U M

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Table I, page 16: The designation "Piper Cub PA-11" should be changed to "Piper Cub J3C-65."

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SUMMARY

The take-off performance of light twin-float seaplanes of the personal-owner or military-observation type is investigated by means of typical take-off calculations. It is shown that, in general, the take-off performance of seaplanes of this type is adversely affected by high resistance at planing speeds. Various means are suggested for reducing this resistance and obtaining large reductions in the required take-off time and distance. Design considerations for twin floats for landplane conversions are discussed, and procedures for using existing data for estimation of their take-off characteristics are outlined in an appendix.

INTRODUCTION

Twin-float seaplanes of the personal-owner or military-observation type are usually conversions of existing small landplanes in which the landing gear is replaced by standardized floats with the minimum of other alterations to the basic designs. Their take-off performance is dominated by inherent aerodynamic and power-plant characteristics of the type and by the buoyancy and stability requirements of the float system.

A survey of contemporary light airplanes indicates that there are two categories of interest from the point of view of take-off performance. The first, referred to as category 1, includes the smaller slow-speed types with high power loadings (above 18 lb per hp). Airplanes in this category usually have very low wing loadings and take-off speeds but, on the other hand, have high parasite-drag coefficients, which affect take-off performance adversely. The second, referred to as category 2, includes larger, aerodynamically cleaner types with relatively high wing loadings (above 14 lb per sq ft). Airplanes in this category are usually higher powered but have high take-off speeds for the size of their floats, that is, high values of the Froude number (Speed/$\sqrt{\text{Linear dimension}}$).

In order to investigate the problem of water resistance for airplanes of the type considered, take-off performance calculations were made for a hypothetical twin-float seaplane in each category. The results are indicative of the importance of resistance in the development and operation of small water-based airplanes. The procedure followed illustrates the application of existing data to the design of twin floats for light airplanes.

AIRPLANE SPECIFICATIONS AND CHARACTERISTICS

Typical specifications and computed characteristics for airplanes in both categories of interest, published in reference 1, are listed in table I. These airplanes are representative of light-plane types capable of conversion to twin-float seaplanes, and their characteristics provide appropriate assumptions for calculating specific take-off performance in each category.

The airplanes of category 1 have wing loadings of about 7 combined with the high power loadings. With an assumed propeller efficiency of 0.80, the calculated parasite-drag coefficients based on the listed maximum speeds vary from 0.033 to 0.067. The airplanes of category 2 have power loadings of from 14 to 16 pounds per horsepower combined with the higher wing loadings. The parasite-drag coefficients of the second category vary from 0.016 to 0.032.

Geometric aspect ratios average 7.5 for the first category and 6.9 for the second; there is no essential difference between the two groups in this respect. The effective aspect ratios during take-off will be higher for both because of ground effect.

Two-blade propellers with tip speeds below 850 feet per second are employed for all the airplanes considered. Those for the first category are the simple fixed-pitch type, whereas those for the second require high enough blade settings at maximum speed to justify the use of controllable pitch for adequate take-off performance.

TAKE-OFF CALCULATIONS

Airplane Characteristics

The airplane characteristics assumed for the take-off calculations, based on the specifications listed in table I, are given in table II. Seaplane A is representative of category 1, the large class of personal airplanes used for sport flying. Seaplane B is representative of the higher-performance light planes of category 2 used for advanced sport, commercial, and military purposes.

The effective aspect ratio including ground effect for both seaplanes is arbitrarily assumed as 8.0. This assumption has a minor effect on the results of the calculations.

The assumed values of parasite-drag coefficient excluding floats correspond to relatively high and low values in table I. In selection of these values it was assumed that, in a conversion, the drag of the fixed landing gear is replaced by that of the strut system supporting the floats. The aerodynamic drag of the floats themselves during take-off is included in the water-resistance data from tank tests at the Langley Laboratory of the National Advisory Committee for Aeronautics.

Wing and Propeller Characteristics

Lift and drag.- A rectangular unflapped wing having an NACA 23012 section was assumed for both seaplanes. Lift and drag coefficients of this wing for an aspect ratio of 8.0 were estimated from figure 15 of reference 2 and are plotted herein against angle of attack in figure 1.

The angles of wing setting chosen (see table II) represent the usual compromise between a high setting favorable for take-off and a low setting favorable for flight. The values assumed for each seaplane are representative of practice.

Thrust.- The thrust in the take-off range for each seaplane was estimated from figure 7 of reference 3. The same blade angle was assumed for both. Computations of the thrust for seaplane B at the blade angles required for flight conditions indicate that controllable propellers with low blade angles during take-off are usually required for seaplanes in this category.

Float Characteristics

The primary requirements for twin-float systems for landplane conversions are:

(a) Sufficient surplus buoyancy for flotation and seaworthiness

(b) Sufficient length and spacing for longitudinal and lateral stability at rest

(c) Low enough water resistance for take-off

(d) Adequate hydrodynamic stability and control

(e) Adequate spray control for prevention of damage and corrosion

(f) Minimum effect on aerodynamic characteristics in flight

Conventional floats meeting the requirements named are fairly well standardized. They usually have length-beam ratios from 7 to 8, beam-height ratios of about 1.0, and surplus buoyancies of about 100 percent. Decks and bows are rounded for streamlining, and sterns are adapted for some form of water rudder. The bottoms consist of forebody and afterbody planing surfaces separated by a transverse step and having angles of dead rise ranging from 20° to 30°. Spray is controlled by spray strips or chine flare, whichever is more consistent with the general construction.

An NACA float suitable for light planes is shown in figure 2. Offsets, static properties, general resistance data, and aerodynamic-drag data for this form are available in reference 4.

Float Size and Dimensions

The size of the floats must be kept as small as possible compatible with flotation, seaworthiness, and spray requirements to minimize adverse aerodynamic effects in flight. Large floats have smaller resistance at the hump and correspondingly larger resistance near take-off. Experience has indicated the latter to be critical for small seaplanes.

NACA model 57-B-5 was tested for values of load coefficient C_Δ as high as 1.80. The submerged displacement in sea water corresponds approximately to a value of load coefficient of 3.25. If the gross load coefficient C_{Δ_o} is assumed to be 1.80, the surplus buoyancy is

$$\left(\frac{3.25 - 1.80}{1.80}\right)100 = 80 \text{ percent}$$

This value is the minimum desirable for ordinary service, although some military floats have been designed for less. A value of design gross load coefficient of 1.80 is thus a maximum value for a float of conventional proportions to favor aerodynamic performance and high-speed water resistance.

The forebody of model 57-B-5 has a value of length-beam ratio L_f/b of 4.17. At a value of gross load coefficient of 1.80 the spray coefficient k (reference 5) is

$$\frac{C_{\Delta_o}}{\left(\frac{L_f}{b}\right)^2} = \frac{1.80}{(4.17)^2} = 0.103$$

This value of k corresponds to excessive low-speed spray for multiengine flying boats. It is believed, however, to be acceptable for twin-float seaplanes because of the larger clearances of the type as compared with flying boats.

With a value of gross load coefficient of 1.80, the over-all dimensions of twin floats similar to model 57-B-5 for the hypothetical seaplanes become

	Seaplane A	Seaplane B
Beam over spray strips, feet	1.755	2.215
Length, feet	13.23	16.70
Height, feet	1.61	2.02

These dimensions are comparable with those of commerical floats for similar seaplanes. Even the minimum size of float is large compared with other airplane components; thus, some compromise of seaworthiness and spray characteristics to achieve the best over-all results is justified.

Procedure

The take-off calculations consist of computing the total resistance and thrust available at various speeds for the assumed conditions and determining the variation of net accelerating force with speed, the take-off time, and take-off distance from these results. The variation of friction forces with scale may usually be neglected; and, at practical float spacings, interference effects on the resistance may be considered negligible. Because the take-off problem is greatest in a flat calm, it is assumed that there is no wind. Details of the calculations are given in the appendix.

For seaplanes A and B the floats were considered to be free to trim (zero trimming moment about the center of gravity) up to a speed beyond the hump speed where planing on the forebody alone is well established. The remainder of the take-off was considered to be at a trim of 6° (near the trim for minimum water resistance). The high-speed portion of the run was also calculated for a trim of 8° (the highest obtainable without transferring the entire load to the afterbody) in order to investigate the effect of reduction in take-off speed by this means.

The speed coefficients and load coefficients involved in the take-off of seaplane A are within the range of the tank data for the float (reference 4). The values of the coefficients for seaplane B at planing speeds, however, are outside the scope of the tank data, and the water resistance during the planing run must be estimated by other means. The method employed is also given in the appendix.

RESULTS AND DISCUSSION

The results of the calculations are plotted in the usual form against speed for seaplane A in figure 3 and for seaplane B in figure 4. The net accelerating force (difference between thrust and total resistance) at the first hump is large for both seaplanes but becomes very small near take-off at either 6° or 8° trim. This distribution of the acceleration is in general accord with operating experience with light seaplanes. The effects are, however, somewhat exaggerated because of the assumption of no wind and because of the favorable scale effect on frictional resistance not taken into account in the calculations.

The take-off speeds corresponding to the estimated lift coefficients and assumed trims are high as compared with reported landing speeds of light airplanes but are representative for seaplane operation in the absence of wind and for the angles of attack corresponding to the wing settings assumed. The float trims are the maximum obtainable with the step in the water near take-off. The take-off speeds could be reduced by higher angles of wing setting but such settings would result in larger negative attitudes of the floats in flight.

The lines drawn between total resistance and thrust on a slope of gross weight W over the acceleration of gravity g plotted on the force and speed scales respectively, represent one-second intervals during the take-off (reference 6). The distance traveled each second is equal numerically to the mean speed during that second. Total take-off time is the sum of the vertices formed by the lines, and take-off distance is the sum of the speeds at each vertex. The take-off performance determined in this manner is included in figures 3 and 4.

Both seaplanes pass through the first hump in a few seconds but the total take-off time is inordinately long because of the proximity of thrust and resistance near take-off. Increasing the trim from 6° to 8° reduces the take-off speed but increases the total resistance. Consequently, no gain in over-all performance can be expected by pulling up unless the available elevator moment is sufficient to pull the main step clear and eliminate the high resistance caused by the fact that the afterbody runs in the wake of the forebody.

The high resistance near take-off illustrated by the results of the calculations immediately suggests a means of making a large improvement in the design of floats for light seaplanes and floats which operate at very high water speeds in general. The high resistance is inherent in conventional floats because of insufficient afterbody clearance and may be greatly reduced by increasing the clearance if the primary functions of the afterbody are not unduly impaired.

Afterbody clearance may be increased by displacing the forebody and afterbody vertically and by thus increasing the depth of step. This modification has a small adverse effect on the low-speed hump resistance, which is not critical, but increases the drag in flight and the structural discontinuity. The adverse effects may be minimized by a suitable step fairing.

The need for increased afterbody clearance also suggests the application of the NACA planing-tail hull (reference 7) to seaplane float systems. This form has extreme afterbody clearance and low resistance at all speeds without undue penalty in aerodynamic drag (reference 8).

In order to evaluate the possible improvement at high planing speeds offered by the planing-tail hull, take-off calculations were made for seaplane B at 6° and 8° trim, comparable to those of figure 4, using the resistance data for Langley tank model 163A-11 (reference 7). This elementary hull (fig. 5) has an over-all length-beam ratio of 8.0 and a forebody length-beam ratio of 4.0; it is thus comparable in over-all proportions with model 57-B-5. The form of deck, however, must be adjusted to attain the proper distribution of buoyancy for a seaplane float.

The results of the calculations are plotted in figure 6. The large afterbody clearance afforded by the planing-tail form eliminates the high-speed hump characteristic of the conventional float under the same conditions. It also offers the possibility of taking off at higher trims and lower speeds without increasing take-off time or distance. The take-off performance in the planing range from 67 feet per second to get-away compares with that of model 57-B-5 as follows:

Trim (deg)	Model	Time (sec)	Distance (ft)
6	57-B-5	22	2260
6	163A-11	12	1150
8	57-B-5	27	2680
8	163A-11	10	920

Thus, although the differences in performance may be exaggerated by the calculated proximity of the resistance and thrust curves for the conventional float, there is a strong indication that increasing afterbody clearance by a large amount or adapting the planing-tail hull form for floats constitutes the most fruitful means of improving the take-off of light seaplanes.

According to information obtained from technical observers visiting the German DVL tank at Hamburg, resistance at high speeds of a hull with insufficient afterbody clearance may be reduced by a series of small auxiliary steps on the afterbody. An arrangement of such steps reported to have been used on the Blohm and Voss 222 flying boat is illustrated in figure 7. They are essentially small wedges fitted in rows behind the shallow step for the first 50 percent of the afterbody length and their contribution to the aerodynamic drag of the hull would obviously be small. The results of the take-off calculations with conventional floats indicate that strategically located auxiliary steps might provide a simple means of improving the take-off performance of standard floats that "stick" near get-away. For light seaplanes the effect of the steps could best be investigated by experiments on actual floats.

CONCLUDING REMARKS

Light twin-float seaplanes are apt to have poor take-off performance because of high water resistance at speeds near take-off. The development of float forms affording large afterbody clearance and reduction in resistance at planing speeds offers the most promise in improving the take-off performance of the type. The form of the NACA planing-tail hull is of particular interest for application to float systems because of its low resistance characteristics. Further tank tests of planing-tail hulls suitable for floats at higher speeds and loads than heretofore tested would be of value in the field of research on light airplanes.

Langley Memorial Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va., October 29, 1947

APPENDIX

CALCULATION OF TOTAL RESISTANCE

OF A TWIN-FLOAT SEAPLANE DURING TAKE-OFF

Coefficients

The hydrodynamic and aerodynamic coefficients employed in the take-off calculations are defined as follows:

C_{Δ}	load coefficient $\left(\frac{\Delta}{wb^3}\right)$
C_R	resistance coefficient $\left(\frac{R}{wb^3}\right)$
C_V	speed coefficient $\left(\frac{V}{\sqrt{gb}}\right)$
C_L	airplane lift coefficient $\left(\frac{L}{\frac{\rho}{2}SV^2}\right)$
C_D	airplane drag coefficient $\left(\frac{D}{\frac{\rho}{2}SV^2}\right)$

where

Δ	load on each float, lb
R	water resistance plus air drag of each float, lb
V	water and air speed, fps
w	specific weight of sea water (64 lb per cu ft)
b	beam over spray strips for model 57-B-5 or beam of hull for model 163A-11, ft
g	acceleration due to gravity (32.2 ft per sec^2)
L	wing lift, lb
D	airplane drag excluding floats, lb
S	wing area, sq ft
ρ	air density at sea level (0.002378 $lb\text{-}ft^{-4}\ sec^2$)

For the values assumed for seaplanes A and B, the coefficients become

$$\left.\begin{aligned} C_\Delta &= \frac{\Delta}{64(1.755)^3} = \frac{\Delta}{347} \qquad \text{(seaplane A)} \\ C_\Delta &= \frac{\Delta}{64(2.215)^3} = \frac{\Delta}{694} \qquad \text{(seaplane B)} \end{aligned}\right\} \tag{1}$$

$$\left.\begin{aligned} C_R &= \frac{R}{347} \qquad \text{(seaplane A)} \\ C_R &= \frac{R}{694} \qquad \text{(seaplane B)} \end{aligned}\right\} \tag{2}$$

$$\left.\begin{aligned} C_V &= \frac{V}{\sqrt{32.2(1.755)}} = \frac{V}{7.51} \qquad \text{(seaplane A)} \\ C_V &= \frac{V}{\sqrt{32.2(2.215)}} = \frac{V}{8.45} \qquad \text{(seaplane B)} \end{aligned}\right\} \tag{3}$$

$$L = \left(\frac{0.002378}{2}\right) 167 C_L V^2 = 0.1985 C_L V^2 \qquad \text{(seaplanes A and B)} \tag{4}$$

$$D = 0.1985 C_D V^2 \qquad \text{(seaplanes A and B)} \tag{5}$$

Calculations

Free to trim.- For the free-to-trim condition, the resistance coefficient and trim with zero trimming moment at a succession of speed coefficients is obtained from figure 15 of reference 4. Since this figure only includes data up to $C_V = 3.6$, figure 14 (reference 4) is assumed to apply at higher speed coefficients. The steps in the calculation at each speed coefficient are conveniently tabulated as follows:

Symbol	Definition	Source	Value	
			Seaplane A	Seaplane B
Δ_o	Load per float at rest, lb	Table II	625	1250
C_{Δ_o}	Load coefficient at rest	Equation (1)	1.80	1.80
V_G	Get-away speed for 9° trim, fps	Equation (4)	74	108
C_V	Speed coefficient	Assumed	3.6	3.6
V	Speed, fps	Equation (3)	27.0	30.4
V^2	Speed squared, (fps)^2	V^2	730	922
C_{Δ_1}	Approximate load coefficient	$C_{\Delta_o}\left[1 - \left(\frac{V}{V_G}\right)^2\right]$	1.56	1.66
τ_1	Approximate trim, deg	Figure 15 of reference 4	11.5	11.8
α	Angle of attack, deg	τ_1 + Wing setting (Table II)	16.5	15.8
C_L	Lift coefficient	Figure 1	1.34	1.29
L	Lift, lb	Equation (4)	194	236
Δ	Load on float, lb	$\Delta_o - \frac{L}{2}$	528	1132
C_Δ	Load coefficient	Equation (1)	1.52	1.63
τ	Trim, deg	Figure 15 of reference 4	11.3	11.7

These values of load coefficient and trim check the first approximate values closely. If they did not do so, the same operation would be repeated using the last values as the second approximation for C_{Δ_1} and τ_1. The total resistance is then calculated as follows:

Symbol	Definition	Source	Value	
			Seaplane A	Seaplane B
C_R	Resistance coefficient	Figure 15 of reference 4	0.328	0.362
R	Resistance of each float, lb	Equation (2)	114	251
2R	Resistance of twin floats, lb	2R	228	502
α	Angle of attack, deg	τ + Wing setting	16.3	15.7
C_{D_W}	Wing drag coefficient	Figure 1	0.096	0.090
C_{D_P}	Parasite-drag coefficient	Table II	0.060	0.020
C_D	Airplane drag coefficient	$C_{D_W} + C_{D_P}$	0.156	0.110
D	Airplane drag, lb	Equation (5)	23	20
2R + D	Total resistance, lb	2R + D	251	523

<u>Fixed trim, seaplane A</u>.- The calculation for a given trim when the general test data are available is similar to the free-to-trim calculation except that the trim and load are known and the successive approximations are not necessary.

At a trim of 6°, for example, the angle of attack of the wing for seaplane A is 11°. From figure 1, C_L is 0.93, C_{D_W} is 0.049, and C_D is therefore 0.109. Equations (4) and (5) then become simply:

$$L = (0.1985)0.93V^2 = 0.1845V^2 \tag{6}$$

$$D = (0.1985)0.109V^2 = 0.0216V^2 \tag{7}$$

The remainder of the calculation is tabulated as follows:

Symbol	Definition	Source	Value
C_V	Speed coefficient	Assumed	10.5
V	Speed, fps	Equation (3)	78.8
V^2	Speed squared, $(\text{fps})^2$	V^2	6200
L	Lift, lb	Equation (6)	1142
Δ	Load on float, lb	$\Delta_o - \frac{L}{2}$	54
C_Δ	Load coefficient	Equation (1)	0.160
C_R	Resistance coefficient	Figure 14 of reference 4	0.175
R	Resistance of each float, lb	Equation (2)	61
$2R$	Resistance of twin floats, lb	$2R$	122
D	Airplane drag, lb	Equation (7)	134
$2R + D$	Total resistance, lb	$2R + D$	256

Fixed trim, seaplane B.- The values of speed and load coefficients involved in take-offs of the category represented by seaplane B are outside the scope of the available tank data in reference 4. The water resistance of seaplanes in this category at planing speeds may be estimated by assuming that the load-resistance ratio Δ/R or C_Δ/C_R is constant for a given value of the planing coefficient (reference 9)

$$K = 2 \frac{C_\Delta}{{C_V}^2}$$

The planing coefficient may also be written as

$$\frac{\sqrt{C_\Delta}}{C_V}$$

which is a more convenient form for plotting.

Plots of Δ/R against the parameter $\sqrt{C_\Delta}/C_V$ at various values of C_Δ for model 57-B-5, derived from figure 14 of reference 4, are shown herein in figures 8 and 9 for trims of 6° and 8°, respectively. Similar plots for model 163A-11, derived from figures 5, 6, and 7 of reference 7, are shown herein in figures 10 and 11. It is seen that the data for both the conventional and planing-tail forms "collapse" well enough in this form to permit estimation of Δ/R by the use of a single mean curve until actual test data at higher speeds and loads become available. The mean curves shown were used in the present calculations. The procedure is essentially the same as before and may be conveniently tabulated for seaplane B as follows:

$$\tau = 6^\circ \qquad C_{D_w} = 0.042$$
$$\alpha = 10^\circ$$
$$C_L = 0.86 \qquad C_D = 0.062$$

$$L = (0.1985)0.86V^2 = 0.171V^2 \tag{8}$$

$$D = (0.1985)0.062V^2 = 0.0123V^2 \tag{9}$$

Symbol	Definition	Source	Value	
			Model 57-B-5	Model 163A-11
C_V	Speed coefficient	Assumed	10.5	10.5
V	Speed, fps	Equation (3)	88.6	88.6
V^2	Speed squared, $(\text{fps})^2$	V^2	7850	7850
L	Lift, lb	Equation (8)	1340	1340
Δ	Load on float, lb	$\Delta_o - \frac{L}{2}$	580	580
C_Δ	Load coefficient	Equation (1)	0.84	0.84
$\sqrt{C_\Delta}/C_V$	Planing coefficient	$\sqrt{C_\Delta}/C_V$	0.0876	0.0876
Δ/R	Load-resistance ratio	Figure 8	3.90	
		Figure 10		4.30
R	Resistance of each float, lb	$\frac{\Delta}{\Delta/R}$	149	135
$2R$	Resistance of twin floats, lb	$2R$	298	270
D	Airplane drag, lb	Equation (9)	97	97
$2R + D$	Total resistance, lb	$2R + D$	395	367

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TABLE I

TYPICAL SPECIFICATIONS AND COMPUTED CHARACTERISTICS FOR LIGHT AIRPLANES

[Specifications from reference 1]

Manufacturer and designation	Gross weight, W (lb)	Wing area, S (sq ft)	Engine horsepower, P (bhp)	Engine speed (rpm)	Wing loading, W/S (lb/sq ft)	Power loading, W/P (lb/hp)	Span, b (ft)	Aspect ratio, A (a)	Maximum speed, V_{max} (fps)	Lift coefficient at V_{max}, C_L (a)	Drag coefficient at V_{max}, C_D (a)	Parasite-drag coefficient, C_{D_p} (a)	Propeller diameter (ft)
Category 1													
Aeronca Chief	1250	175	65	2300	7.1	19.2	36.0	7.4	147	0.280	0.0435	0.0401	6.0
Luscombe Silvaire 8-A	1200	140	65	2300	8.6	18.5	35.0	8.8	169	.253	.0357	.0334	6.3
Piper Cub PA-11	1220	179	65	2300	6.8	18.8	35.2	6.9	122	.386	.0740	.0671	6.0
Taylorcraft Twosome BC-12-D	1200	184	65	2300	6.5	18.5	36.0	7.0	154	.232	.0358	.0334	6.0
Category 2													
Beech Bonanza	2550	178	165	2050	14.3	15.5	32.8	6.0	270	0.165	0.0174	0.0159	7.3
Bellanca Cruisaire Sr.	2100	140	150	2600	15.0	14.0	34.2	8.3	248	.205	.0258	.0242	6.2
North American Navion	2570	184	185	2300	14.0	13.9	33.4	6.1	235	.215	.0289	.0265	---
Waco Aristocraft	3130	197	215	2600	15.9	14.6	38.0	7.3	226	.261	.0350	.0320	---

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(a)

A aspect ratio $\left(\frac{b^2}{S}\right)$

C_L lift coefficient at maximum velocity $\left(\frac{W}{\frac{\rho}{2} S V_{max}^2}\right)$

C_{D_p} parasite drag coefficient $\left(C_D - \frac{C_L^2}{\pi A}\right)$

C_D drag coefficient at maximum velocity $\left(\frac{550\eta P}{\frac{\rho}{2} S V_{max}^3}\right)$

where

η assumed propeller efficiency (0.80)

ρ air density at sea level $\left(0.002378 \text{ lb-ft}^{-4}\text{sec}^2\right)$

TABLE II

ASSUMED AIRPLANE CHARACTERISTICS
FOR TAKE-OFF CALCULATIONS

	Seaplane A	Seaplane B
Gross weight, lb	1250	2500
Wing area, sq ft	167	167
Engine horsepower	66	167
Engine revolutions per minute at rated power	2300	2050
Propeller type	Two blade, fixed pitch	Two blade, controllable pitch
Propeller diameter, ft	6.0	7.3
Propeller blade angle at 0.75 radius	15.0	15.0
Wing loading, lb per sq ft	7.5	15.0
Power loading, lb per hp	19.0	15.0
Effective aspect ratio including ground effect	8.0	8.0
Parasite drag coefficient excluding floats	0.060	0.020
Angle of wing setting referred to float base line, deg	5.0	4.0

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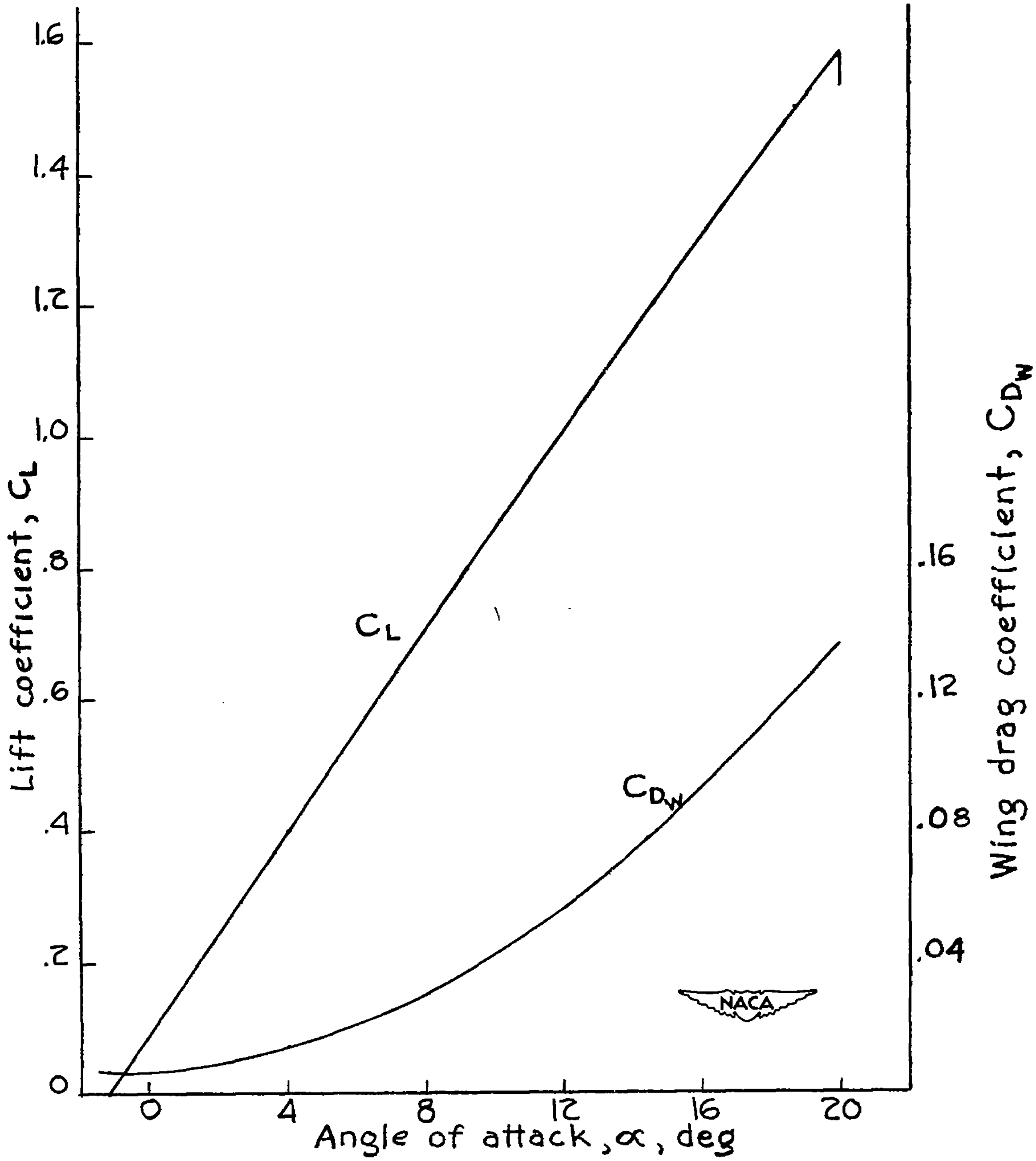

Figure 1.- Assumed lift and drag coefficients for wing of seaplanes A and B. NACA 23012 section. Effective aspect ratio, 8.0.

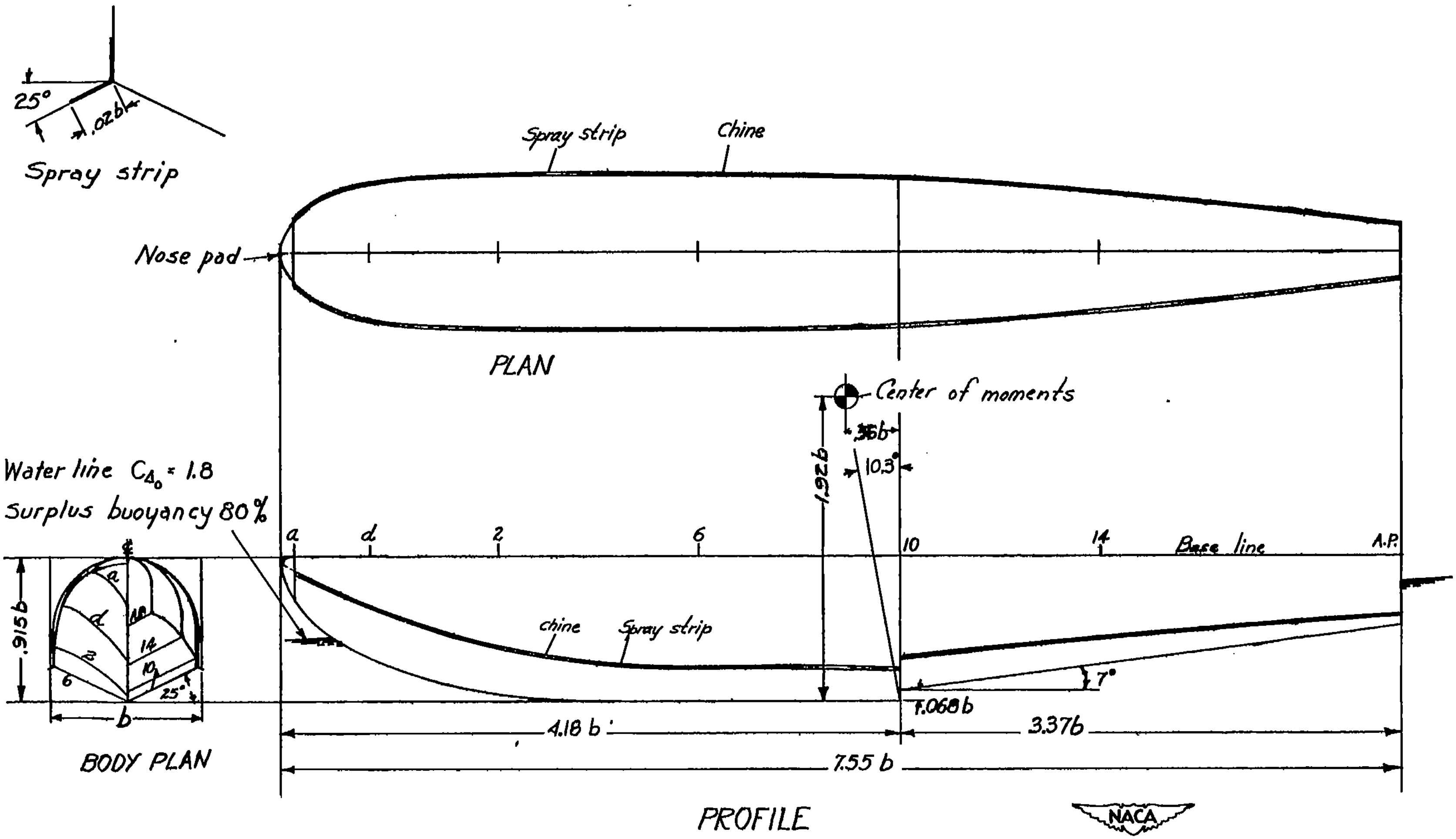

Figure 2.- NACA model 57-B-5. Float for twin-float seaplanes.

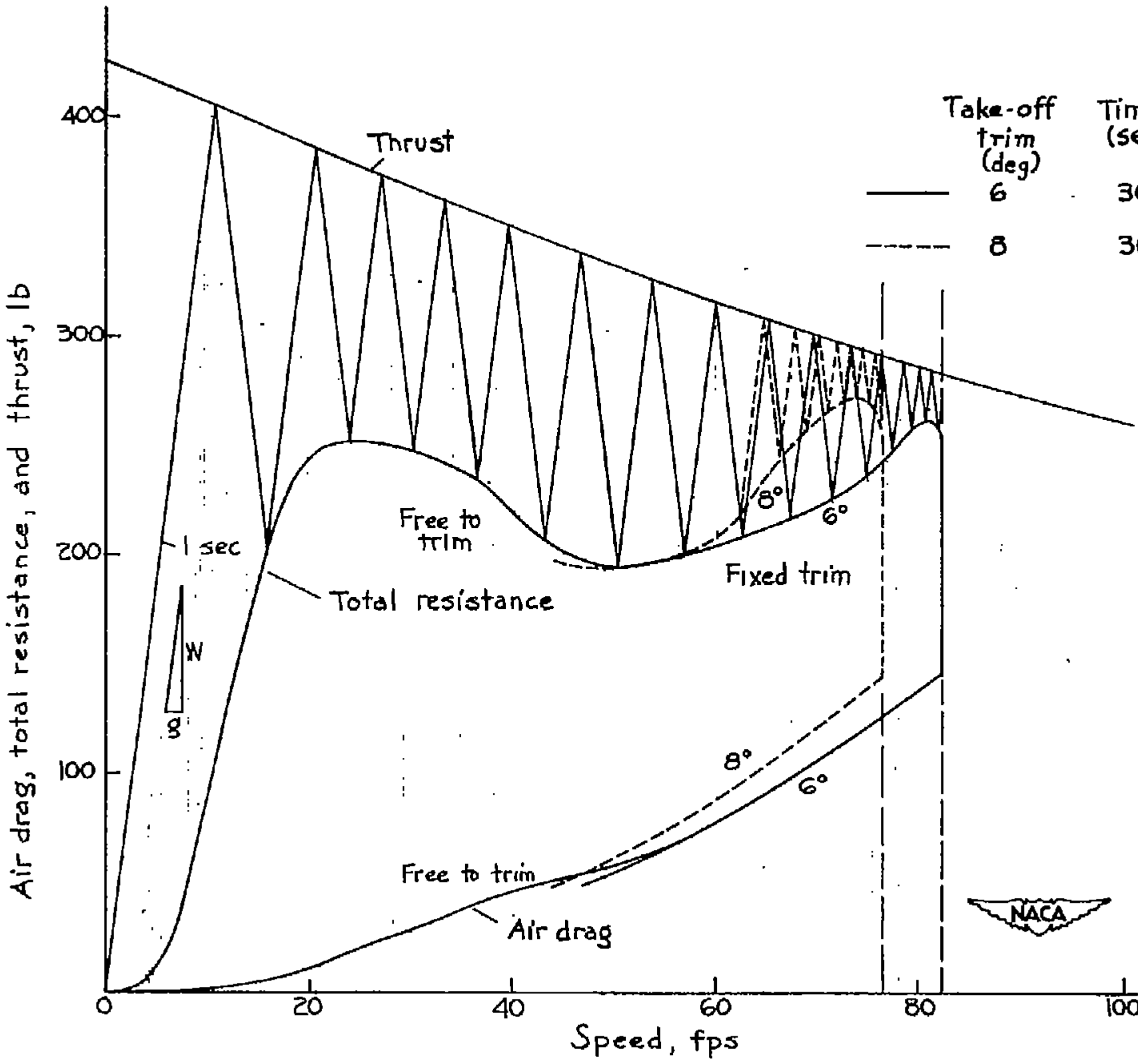

Figure 3.- Results of take-off calculations for seaplane A. Wing loading, 7.5 pounds per square foot; power loading, 19.0 pounds per horsepower; gross weight, 1250 pounds. NACA model 57-B-5, twin floats.

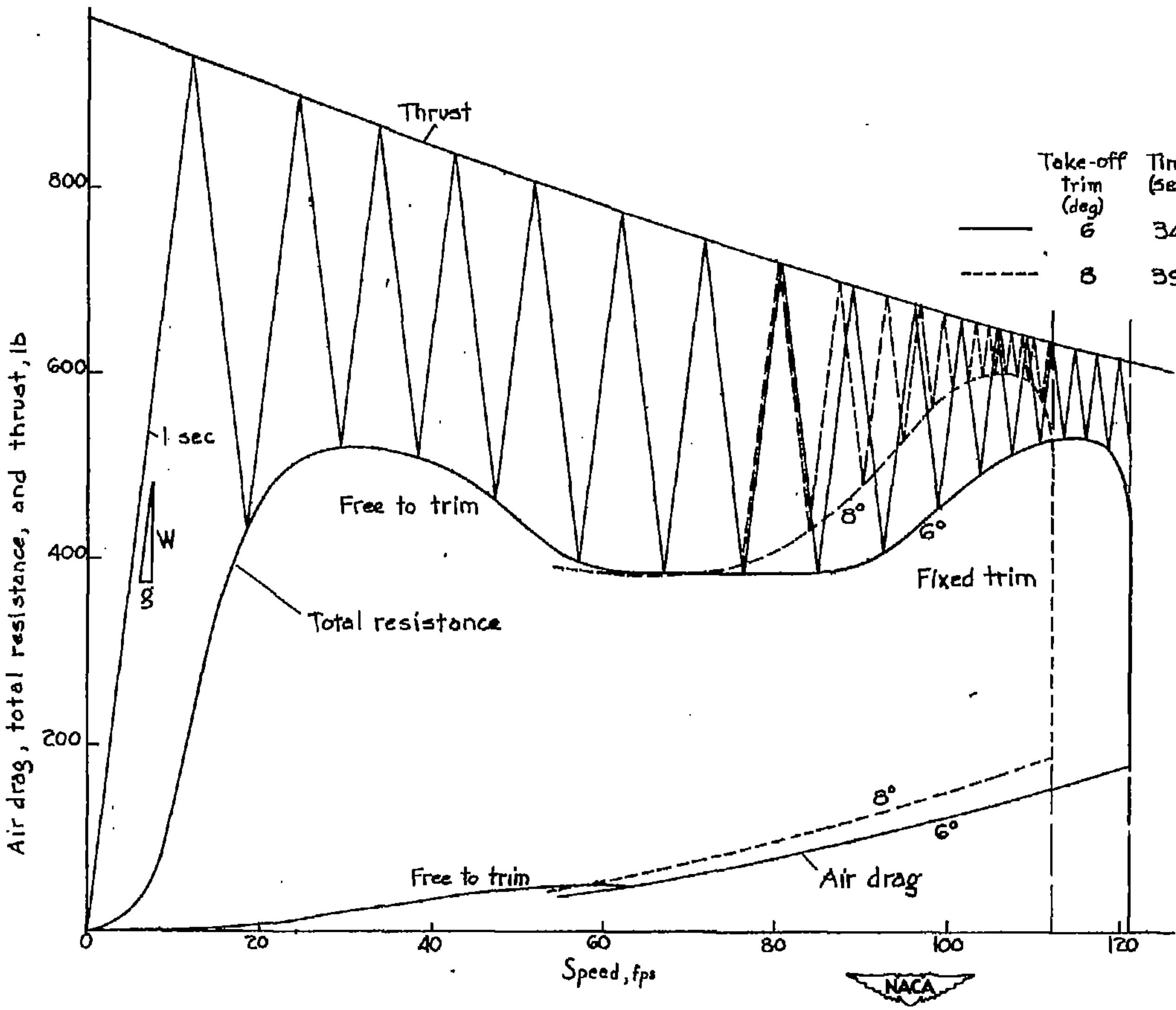

Figure 4.- Results of take-off calculations for seaplane B. Wing loading, 15.0 pounds per square foot; power loading, 15.0 pounds per horsepower; gross weight, 2500 pounds. NACA model 57-B-5, twin floats.

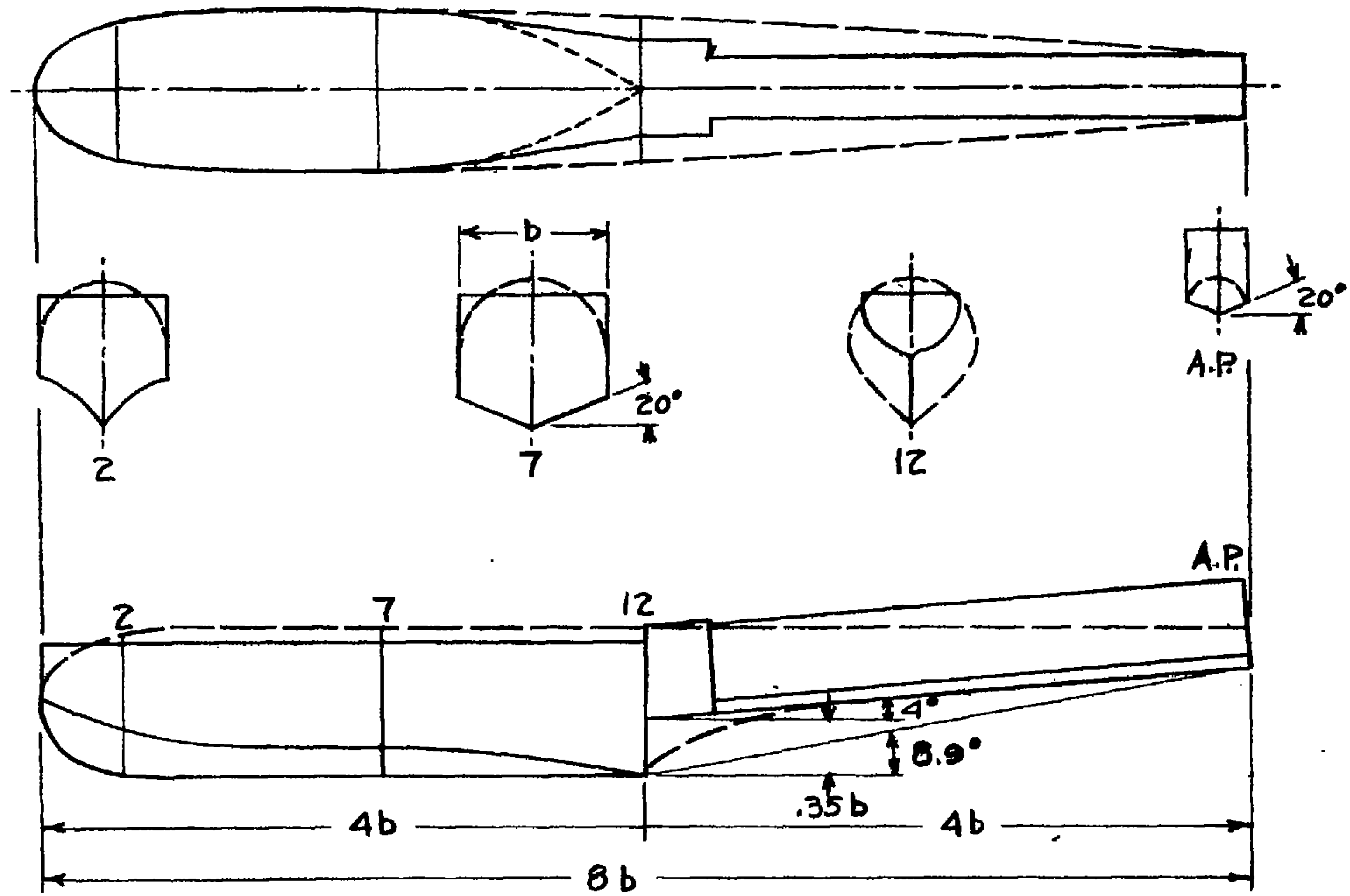

Figure 5.- Langley tank model 163A-11 planing-tail hull. Possible form of float shown by dashed lines.

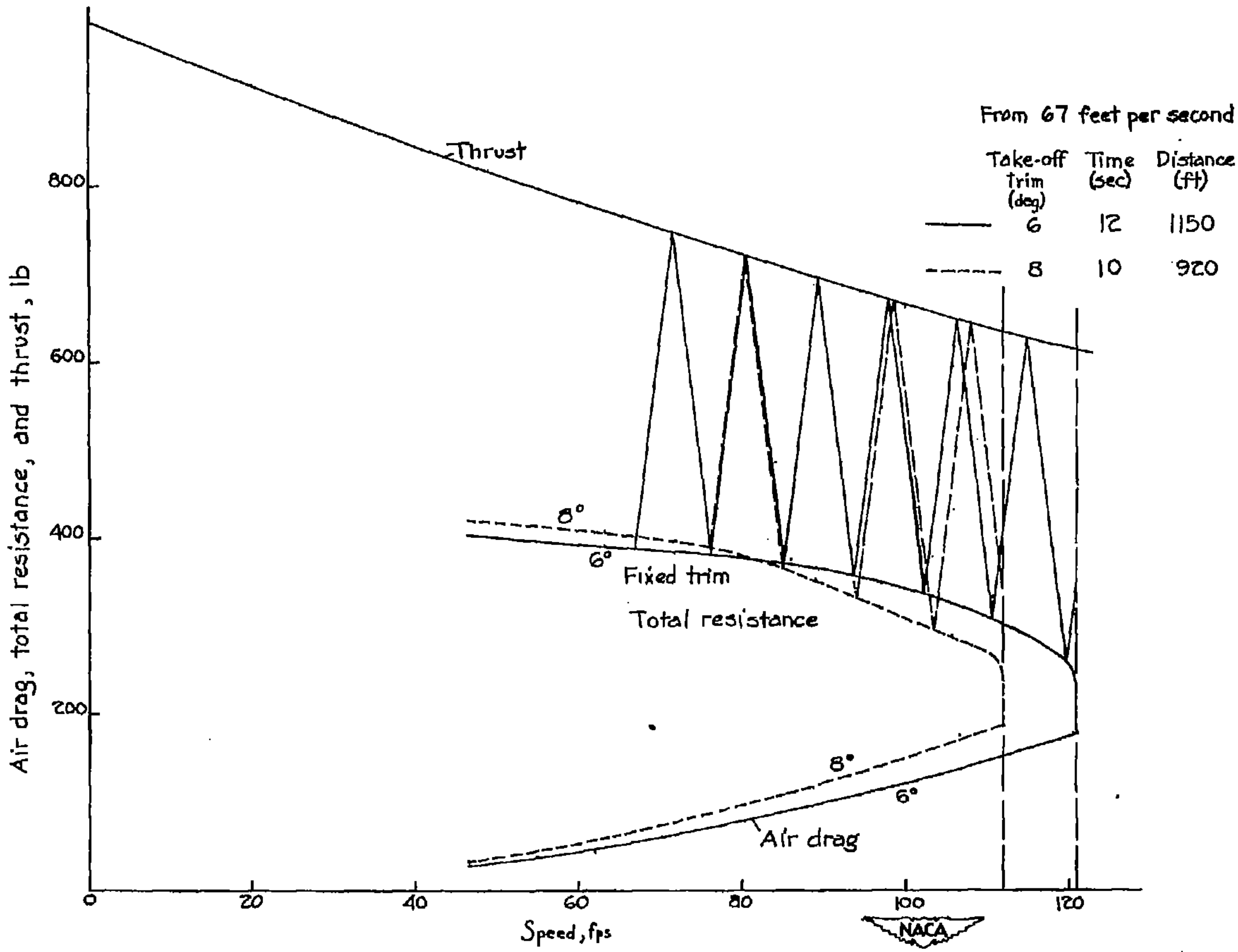

Figure 6.- Results of take-off calculations for seaplane B. Langley tank model 163A-11, twin floats.

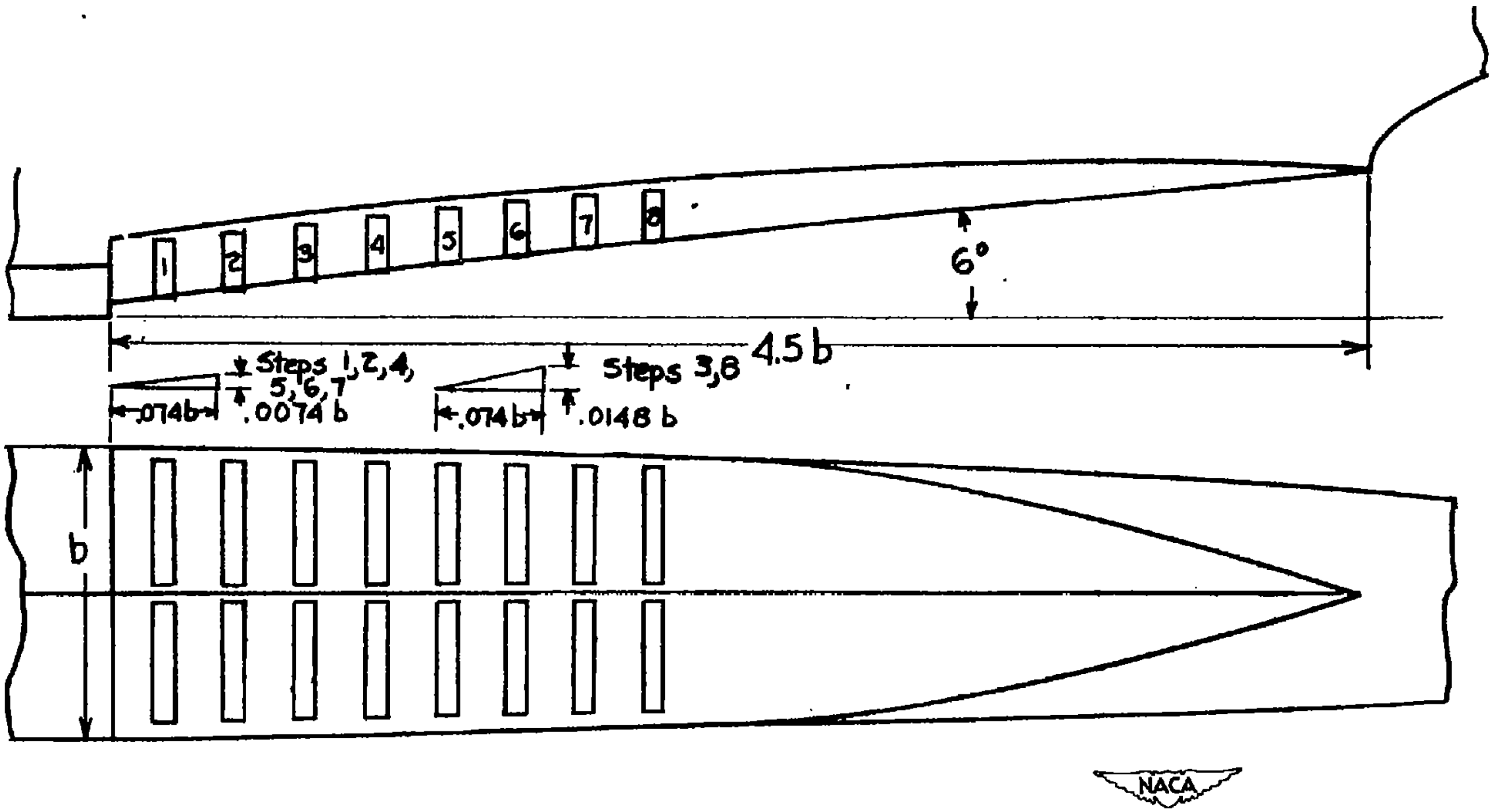

Figure 7.- Auxiliary steps installed on afterbody of German Blohm Voss 222 flying boat.

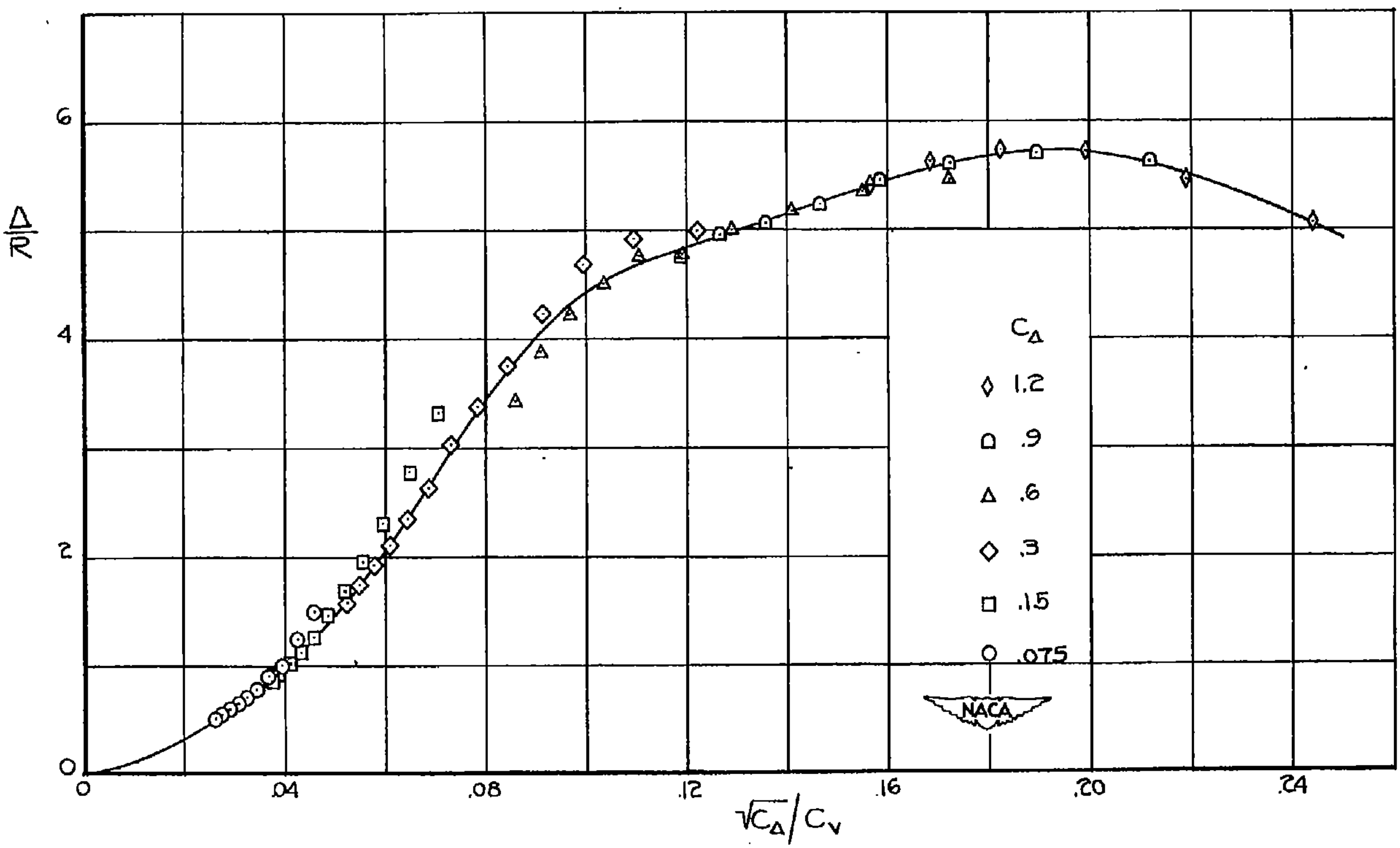

Figure 8.- Chart for estimation of resistance of NACA model 57-B-5 float at high speed and load coefficients. Trim, 6°.

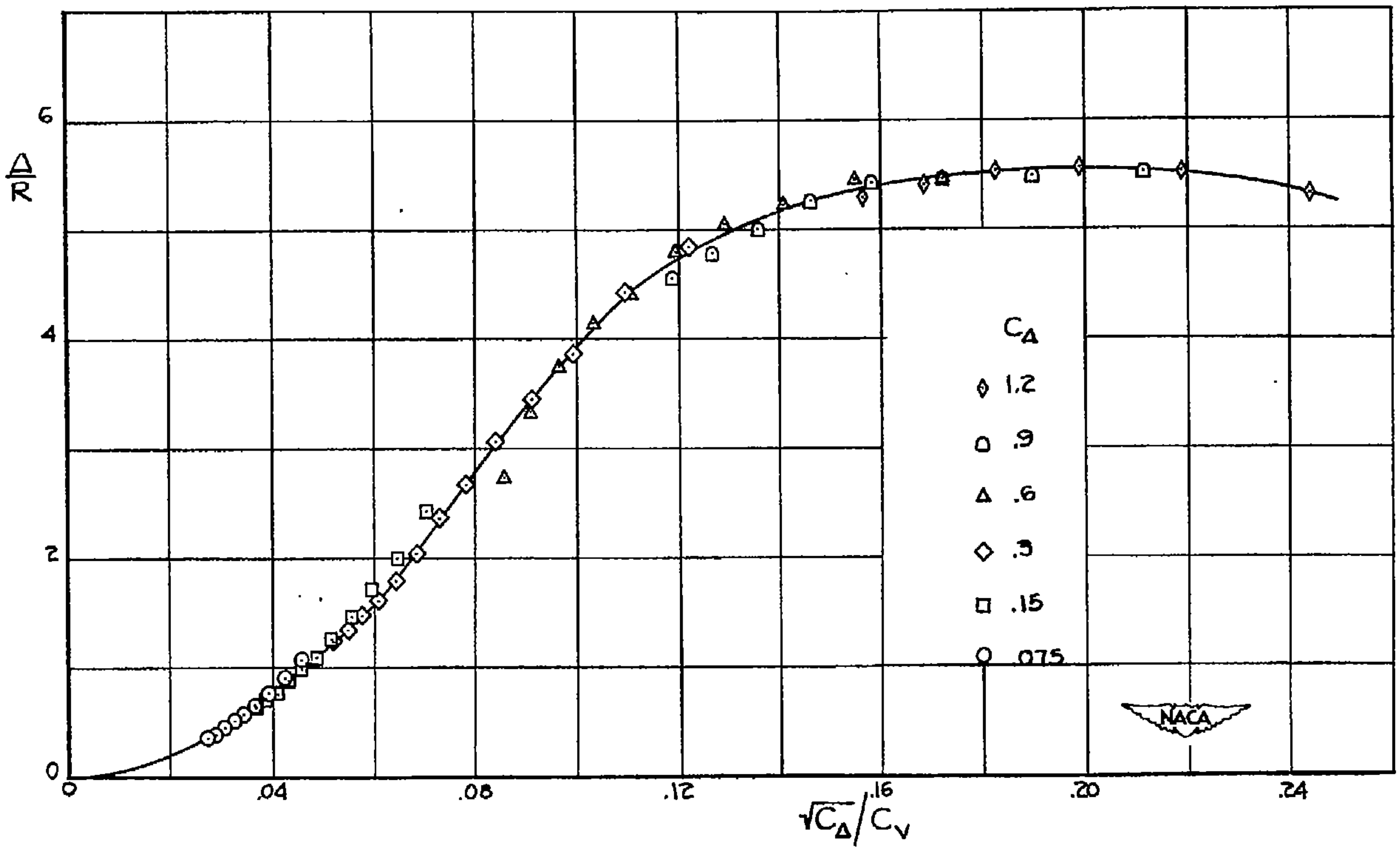

Figure 9.- Chart for estimation of resistance of NACA model 57-B-5 float at high speed and load coefficients. Trim, 8°.

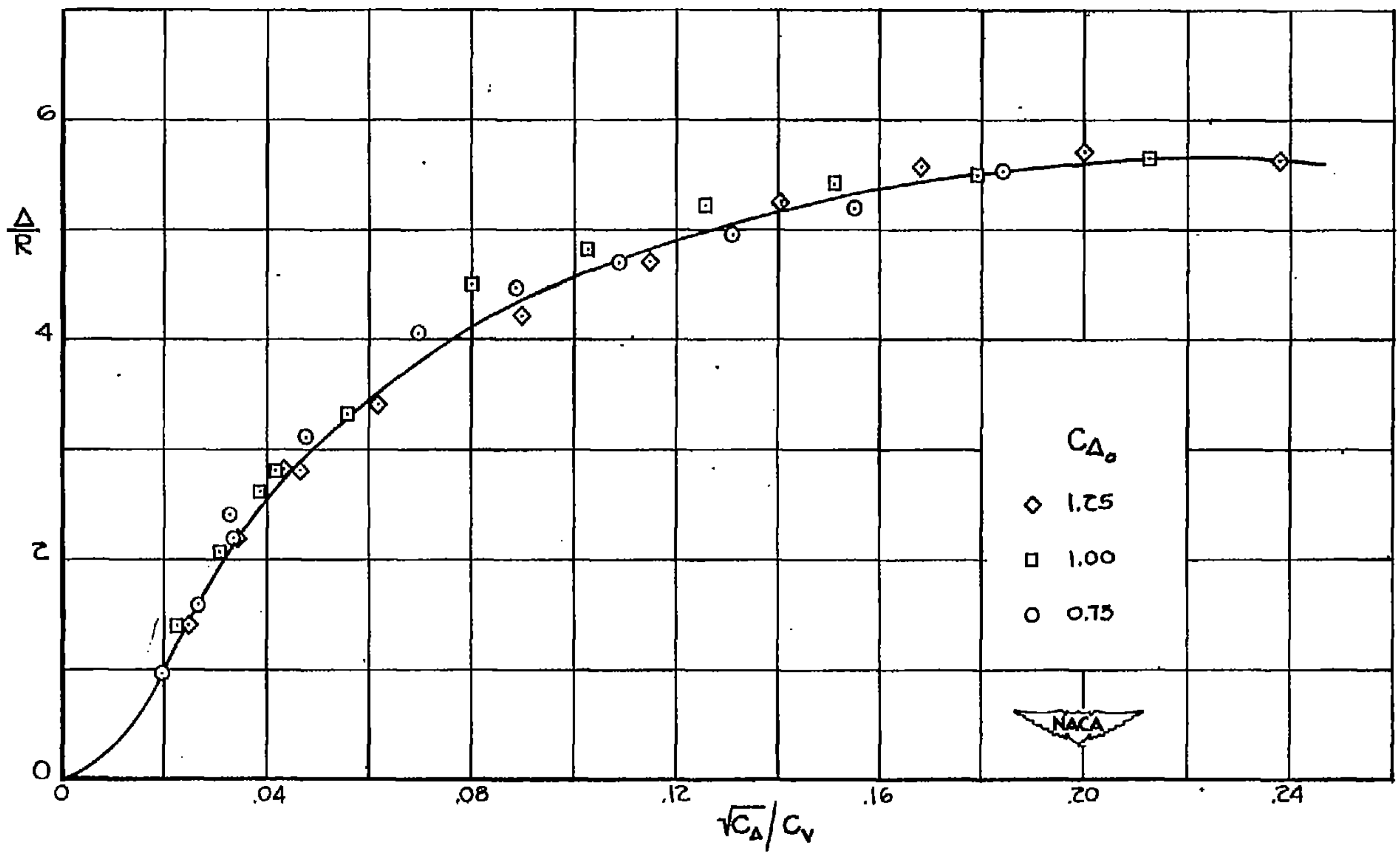

Figure 10.- Chart for estimation of resistance of Langley tank model 163A-11 planing-tail hull at high speed and load coefficients. Trim, 6°.

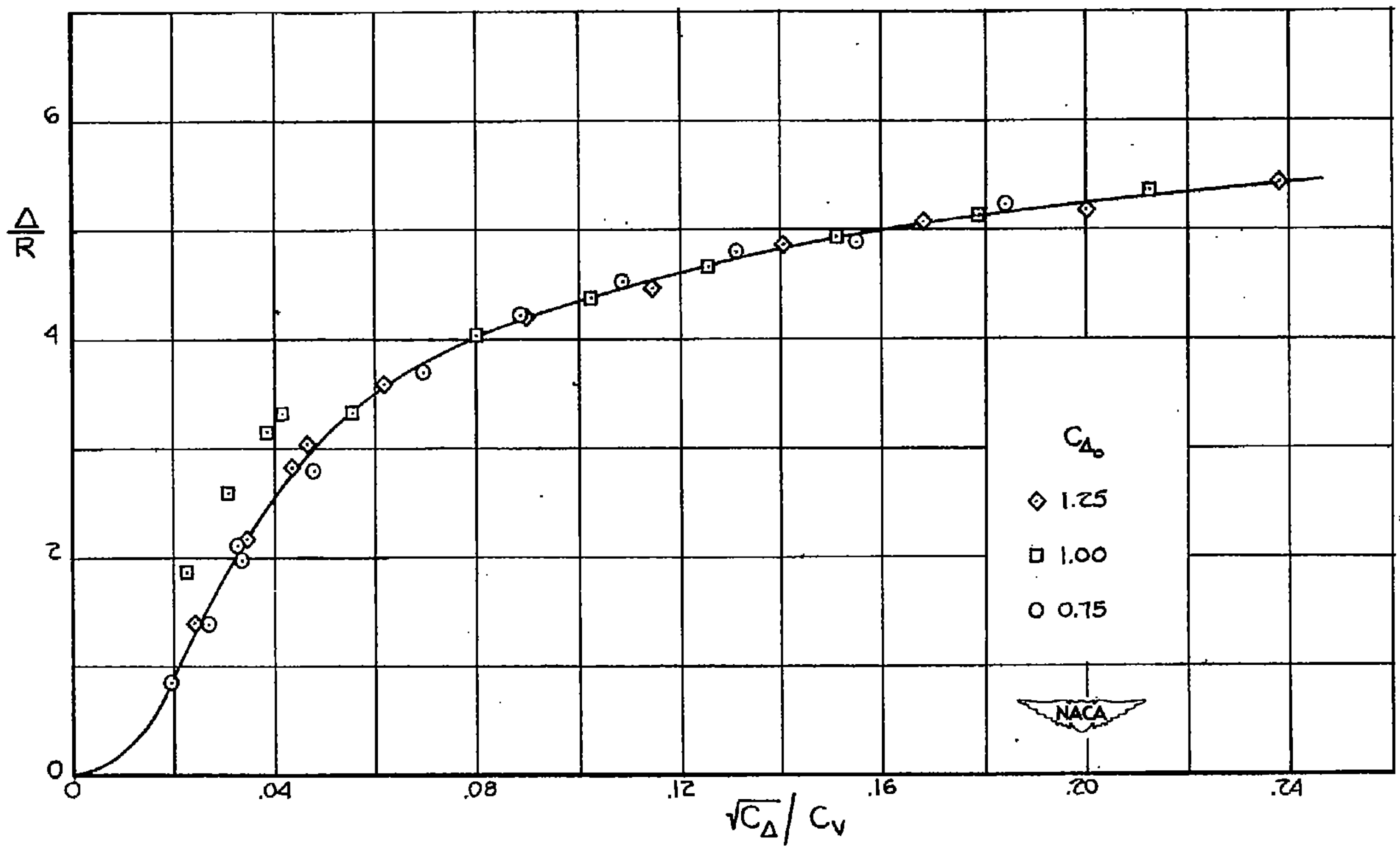

Figure 11.- Chart for estimation of resistance of Langley tank model 163A-11 planing-tail hull at high speed and load coefficients. Trim, 8°.